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REPORT TO THE WESTERN PLANT BOARD ON THE DETECTION
SURVEY FOR KHAPRA BEETLE IN THE WESTERN STATES

The Khapra beetle (Trogoderma granarium) a native of India, Ceylon and Malaya was found to be infesting grain in the central San Joaquin Valley of California in November, 1953. Although this insect had been intercepted a number of times in quarantine, its discovery in warehouses at Alpaugh and Angiola and Tulare County, California, represents the first known infestations of this insect on the North American Continent. In attempting to trace the origin of these infestations and to determine, if possible, the manner in which the insect had gained entry into this country, the California State Department of Agriculture developed information that would indicate its presence in the San Joaquin Valley as early as 1946.

At that time the operators of the J. B. Hill Warehouse Company near Fresno first noticed damage to their stored grain by an insect identified by their commercial pest control operator as the black carpet beetle. Despite control measures, including fumigation, that were applied in an effort to control this insect in the J. B. Hill Warehouse, by 1949 the insect had increased to astronomical proportions, and some 300 tons of grain in the warehouse at that time was a total loss. In 1949 the J. B. Hill Company abandoned this warehouse as far as grain storage was concerned. After the warehouse was emptied the interior of the building was gone over carefully with a blow troch and a residual spray applied. Used sacks from this warehouse, however, were moved to Alpaugh and Angiola where they were filled with grain and used as bulkheads between piles of loose grain. This seems to adequately account for these two infestations, for upon inspecting the Hill warehouse in Fresno, cast skins and dead adults were recovered which were determined as Trogoderma granarium. The way by which the insect reached Fresno, however, has not been determined.

On November 20, 1953, the discovery of this insect in California was reported in the Cooperative Economic Insect Survey Bulletin. On the following December 18 an item appeared in the survey bulletin to the effect that dermestid larvae were numerous in a grain warehouse at Phoenix, Arizona. This report was investigated by the office of the State Entomologist, and the specimens submitted were identified as the Khapra beetle, thus authentically establishing the presence of the insect in that State.

All available literature was reviewed and correspondence with entomologists in countries in which infestations were known to exist was begun by both Federal and State workers to develop information that would be of assistance in controlling this pest. Some pertinent facts that were developed are as follows:

1. In every country in which this insect is known to occur, it is ranked as the most serious pest of stored grain and grain products.
2. The life cycle is completed in from 35 to 100 days depending on temperature; 85°-90°F. is optimum.
3. The insect prefers warm dry weather; development is normal in grain with a moisture content as low as 2%, yet it will stand some freezing and is a serious pest in malt houses in England.
4. There are five instars in the development of the larvae and the cast skin is shed following each instar.
5. Each female lays an average of 120 eggs, and the larvae have been known to live for three years or more without food.
6. The larvae are cosmopolitan feeders, attacking all grains and grain products. In this country it has been found in wheat, oats, rye, barley, flax seed, pinto beans, black-eyed peas, and alfalfa seed. Under confined conditions at Mesa, Arizona, it is completing development on all grain and grain products including bread, crackers, noodles, macaroni, etc., as well as soy beans, peanuts, castor beans, and several other articles.
7. Wherever it exists it is difficult to control. In California, for car lot fumigation, it is recommended that the average dosage for other insects be doubled for the Khapra beetle.

In the early spring the Standard Quarantine Committee of the Western Plant Board petitioned the Federal Department of Agriculture for assistance in conducting a detection survey to determine the general distribution of this insect in the Western States. The work was assigned to the Economic Survey Section of the Plant Pest Control Branch. Dr. R. T. Cotton, Stored Grain Specialist of the Agricultural Marketing Service, U. S. Department of Agriculture, and Mr. K. S. Rohwer of the Plant Pest Control Branch were

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made available to assist with this work. The survey was begun in early April and since several infestations of the insect were known to exist in southern Arizona and southern California only observational surveys were made in these States.

State Plant Pest Control officials were asked to assist in planning the survey for their State and to provide inspection assistance for conducting the work. In each of the States valuable assistance was obtained in selecting the routes to be followed and the mills to be inspected. In Arizona and California the State people were most helpful in assisting us in becoming familiar with the habits of the insect in the known infested properties and in devising a satisfactory procedure for the inspection. Nevada, Utah, Oregon and Washington supplied personnel from their regular force for the survey in those States.

In each State we attempted to survey representative grain handling establishments in the various parts of the State, with particular attention being directed to the larger wholesale establishments. Primary consideration was also accorded feed mixing plants for it was found that such places usually had a wider assortment of materials from different parts of the country. For instance, it might be found that a farmers' co-operative warehouse would have on hand several hundred tons of barley, wheat, and the like, all of local origin, while the poultry or dairy producers association in the same town would have a smaller tonnage of each on hand, but the stock would include local barley or wheat as well as cotton seed meal from Arizona or California, soy bean meal from Minnesota, corn from Iowa, copra meal from the Philippines, etc. All of these establishments were carefully inspected, and in connection with this inspection an attempt was made to determine the material distribution pattern for the Western States.

Briefly these general statements can be made:

Feed grains, barley and wheat for the most part, from Arizona and California have but limited distribution to the north and east. These products are seldom found in warehouses for feed mills in other States. Some of these materials do move into Nevada, Utah, and occasionally Colorado, but not in appreciable quantities.

Cotton seed meal and cake for the territory west of the Rockies is supplied almost without exception by firms in Arizona and California.

Arizona Certified Sorghum Seed is prized throughout the Western States and moves in considerable quantity not only into states represented by the Western Plant Board but to other states further east, Texas, Oklahoma, Kansas, etc.

The burlap business is much larger than one might at first suppose; and of the area that we have surveyed, Los Angeles, San Francisco and Portland supply most of the territory.

In this survey no attempt was made to ascertain to what degree rice from California moves into the other States.

Inspections of warehouses by States were as follows:

Utah - 77	Idaho - 29	Washington - 16
Colorado - 67	New Mexico - 21	Texas - 6
Oregon - 36	Nevada - 19	

Totals are not indicated for Arizona or California since the inspections made in these States during this survey were few in comparison with the total number of inspections that have been made by the State people. In Arizona it is known that most of the commercial warehouses in the State have been inspected. In California some 150 warehouses throughout the State, including the San Francisco Grain Terminal, have been inspected on one or more occasions. It is not believed for the purpose of this detection survey that inspections are necessary in Wyoming or Montana.

Infestations now known to exist are as follows:

<u>Arizona</u>	<u>California</u>	<u>New Mexico</u>
Maricopa County - 5	Imperial County - 5	Roosevelt County - 1
Pinal County - 1	Kern County - 2	Curry County - 2
Pima County - 1	Riverside County - 1	
Yuma County - 3	Tulare County - 2	
Mohave County - 1	Fresno County - 1	
Total 11 infestations in 5 counties	Total 11 infestations in 5 counties	Total 3 infestations in 2 counties

There are 25 known infestations of Khapra beetle in 12 counties of 3 States.

It would be safe to assume that the account outlined in the first few paragraphs of this report adequately explains the infestations at Alpaugh and Angiola. No attempt has been made to trace the source of the other 9 established infestations in California or the movement of the insect to Arizona and its subsequent spread there. That the insect has not been in Arizona or, in fact, established at several of the locations in California for very many years, is indicated by the degree to which the infestations have become generally distributed throughout the establishment in which it is found. One example will suffice. The Southwest Feed and Seed Company at Glendale, Arizona, is one of the larger establishments in the State in which an infestation has been found to exist. This establishment covers half or more of a city block. The building is divided into 4 sections, separated one from the other by sheet metal walls that are none too tight, and they are far from insect proof. The infestation as we know it to exist at Southwest Feed and Seed is confined to one of these sections. In fact, the insects are numerous in less than half of this section. It is not intended to infer that our inspections have been sufficiently thorough to insure the lack of a single specimen in other parts of the plant; they have, however, been far from superficial. The same condition exists at every other infestation in the State that we have visited.

The infestations in New Mexico are all of recent establishment. The infestations at Portales and Texico are attributable to the shipment of sorghum seed for this year's planting from an infested establishment in Arizona. The larvae were taken on the sacks at destination. The record of these two shipments together with four others, three of which went to Texas and the other to Oklahoma, was furnished by the warehouseman in Arizona. The sites in Texas and Oklahoma have also been examined but with negative results. The source of the infestation at Clovis is not clear. Larvae which were identified as T. granarium were taken from the outside of sacks of scratch feed at the Curry County Grain and Elevator. Only a few specimens could be found indicating that the infestation was of recent origin. It is believed that some of the sorghum seed sacks from Arizona are responsible for this infestation.

In the conduction of this survey all types of grain storage and milling establishments have been inspected; large establishments such as Colorado Milling and Elevator Company, the Denver Flour Mills Company, The Quaker Oats Company and the Alberts Flour Mills of Portland; small community storage and grinding establishments; and old mills, some that have been in operation for a hundred years or more. In the larger percentage of these mills, irrespective of outside temperatures, the Khapra beetle will find sections, some large, some small, under which it can survive and build up, thus affording a source of injury and contamination to products produced or stored therein.

The habits of the Khapra beetle are such that not only are its host materials hazardous to its spread but any other article that may be stored on the infested premises. The larvae at time of molt and pupation crawl from the grain in great profusion and seek themselves in corners, crevices, or on any article or thing within their range of travel. It is in the larval stage that we would presume the greatest hazard of spread exists.

As soon as the identity of this insect was known, the State Department of Agriculture in both California and Arizona in cooperation with the owners instigated a control program to reduce existing populations. DDT and oil, Lindane, Methoxychlor, and other insecticides have been used. In some instances fumigation of infested material has been resorted to. In California, with the cooperation of the owners, a number of cars of materials from infested warehouses have been fumigated. The prompt action of these organizations has drastically reduced the number of insects present and has correspondingly lessened the hazards of spread. We do not believe, however, that these measures have eradicated the insect from any infested establishment nor have they eliminated the hazard of spread.

CONCLUSIONS

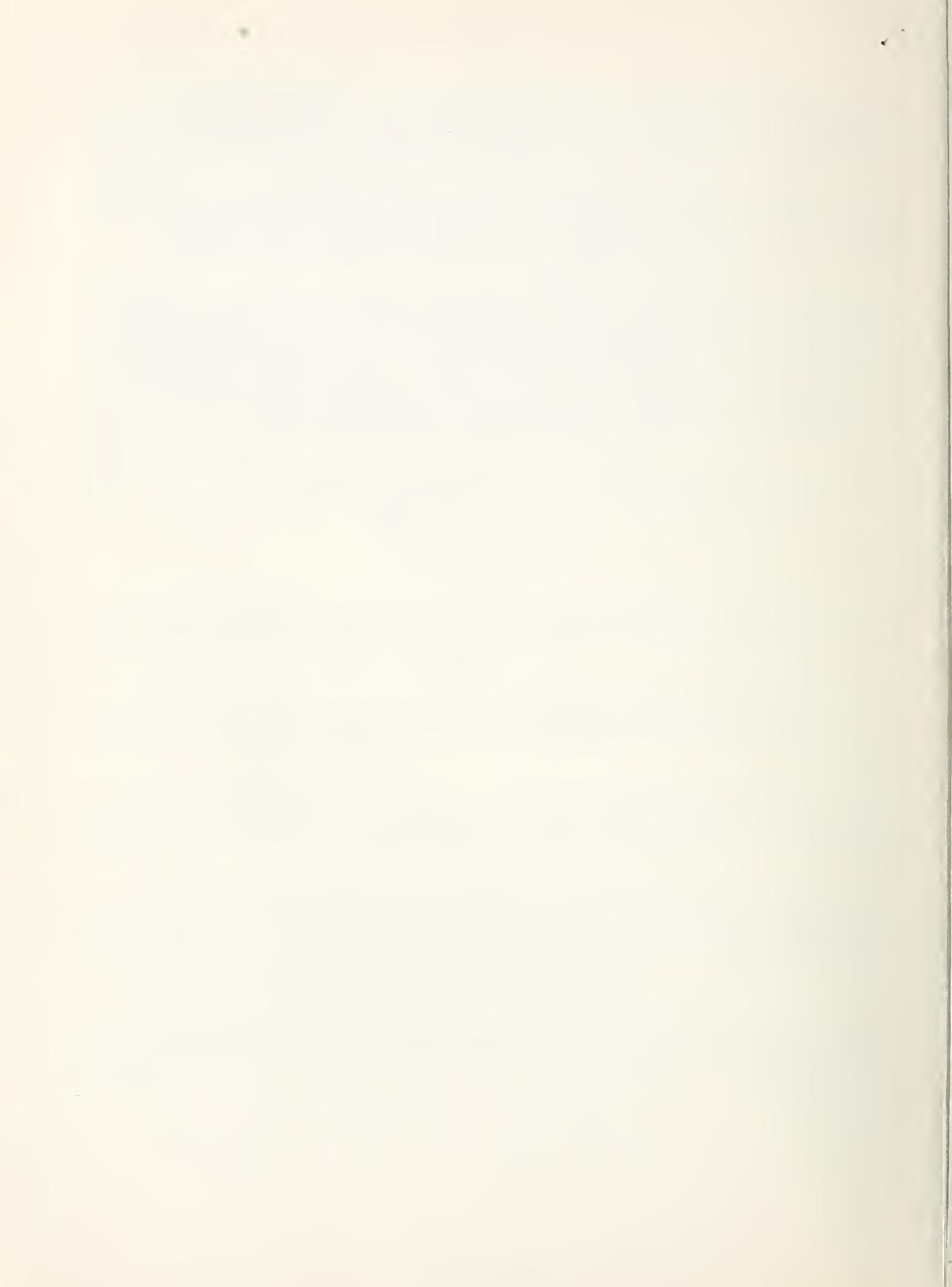
1. The Khapra beetle was in this country as early as 1946. By 1949 the infestation was so serious in the J. B. Hill warehouse at Fresno as to cause its abandonment for grain storage.
2. It was transported in used burlap from the Fresno warehouse to Alpaugh and Angiola in 1949, and by 1953 these infestations had reached serious economic proportions.
3. The manner in which the insect reached other locations in California and Arizona is not clear, but it is doubtful if any of the infestations are as old as the ones at Alpaugh and Angiola.
4. In all probability few of the known infestations reached economic proportions prior to 1953. This is indicated by lack of reports of insect damage from the warehouseman prior to that time and the localized condition of infestations in the majority of the warehouses.
5. The Khapra beetle is not wide spread in the Western States. We may expect that other infestations will be found, but for the most part they will be light and mainly in the areas in which infestations are now known to occur.

6. The Khapra beetle would be a serious pest of stored products throughout the southern half of the United States and could become established in heated mills and warehouses possibly throughout the country.

The report of Dr. R. T. Cotton, this country's leading authority on stored grain pests, following his observations in the infested states is hereto attached as a part of this report. Dr. Cotton's recommendations are heartily concurred in by the writer.

There is also attached a list of the materials on which Dr. Lemac Hopkins of the Arizona Experiment Station has, under confined conditions, reared the Khapra beetle. Dr. Hopkins advises that this list is NOT complete and represents only the materials he has tested. Further work will no doubt add many other products to the host group of this insect.

L. J. Padget



KHAPRA BEETLE SURVEY

During the period April 3 to April 15, I accompanied Mr. L. J. Padjet and Mr. Karl Rohwer on a survey of grain and feed establishments in California, Arizona, Texas, and New Mexico to determine the spread of Khapra beetle infestations.

Infested warehouses were visited in and near El Centro, California, and Phoenix, Arizona. At these places attempts had been made to control the infestations with residual sprays of DDT, lindane, and malathion without success.

Although these sprays are effective in killing the Trogoderma larvae on contact, the habit of the larvae of crowding into cracks and crevices between cribbing of bin; between partitions, in breaks in the floor and walls, and in soil outside warehouses makes it extremely difficult to reach them. It would seem likely that a portable steam Jenny would be useful in killing the larvae in the places inaccessible to sprays.

In Phoenix heavy infestations were observed in the warehouses of the Capitol Feed and Grain Company, at the Quicks Seed and Feed Company, and the Arizona Flour Mills. At Glendale infestations were observed at the Southwest Flour and Feed Company. In some of these places, infestation was rather general throughout the buildings and in screenings dumps outside the warehouses. In others only one of several rooms was infested. This indicated that in some instances the infestations were incipient whereas in others they must have been established for a year or two at least.

Inquiry established the fact that out-of-state shipments of seed and feed were being made from some of the infested plants without any precautions being taken to prevent the spread of the insect.

Furthermore, feed and used bags were supplied to farmers in the immediate locality of the warehouses, thus providing means for spreading the infestation to the farms.

While in Arizona, a visit was made to the Mesa Branch Experiment Station of the University of Arizona to talk with Dr. L. Hopkins who

was breeding, the Khapra beetle in a variety of foodstuffs. He had found that it would breed freely in all types of seed and dry milled products including such items as castor beans, cotton seed, bread, corn meal, flour, beans, cowpeas, and grains of all kinds.

At Tucson we visited the Entomology Department of the University of Arizona and talked with Dr. L. A. Carruth, Head of the Department, and Dean Eckert, Director of the Experiment Station. They expressed the opinion that the situation was so critical that they felt incapable of dealing with the problem without Federal assistance.

After leaving Arizona, we visited the New Mexico Agricultural College at Las Cruces and talked with Dr. Crawford and Dr. Evers of the Entomology Department and to Mr. Ludwick of the Feed and Fertilizer Control office. Mr. Ludwick furnished us with many names of feed and grain dealers in towns in New Mexico and El Paso, Texas.

We visited such establishments in El Paso, Texas, and in the following towns in New Mexico; Las Cruces, Deming, Roswell, Texico, Clovis, Carlsbad, Tucumcari, Santa Fe, Las Vegas, Albuquerque, and Portales.

In a number of the places visited a few individual larvae of Trogoderma versicolor were taken. At the Curry County Coop. Elevator of Clovis, N. M., a colony of Trogoderma sp. larvae were taken on some bags of old pelleted feed. Specimens were sent in for identification but were presumed to be T. versicolor.

At Portales, N. M., it was found that the Worley Mills had on hand a portion of a shipment of grain sorghum seed that had been received in the spring of 1953 from the Capitol Feed and Seed Co. of Phoenix, Arizona (one of the infested warehouses). On examining this seed it was discovered that all of the bags were infested with the Khapra beetle. It was suggested that these bags of seed and all nearby bags be fumigated at once and the warehouse sprayed with lindane. Orders were given to do this work while we were still there. This infestation places the insect on the eastern border of New Mexico.

It would seem likely that other infested shipments of seed must have been sent out from the infested warehouses in Arizona and possibly California.

Observations would indicate that the build-up of this insect is slow and at this time it would be possible to eradicate it or at least confine it to its present limits. It would be advisable in my opinion to locate all present infestations and attempt to destroy them by the use of residual sprays, fumigation or steam applications.

To have all used bags fumigated.

To clean up and burn over all screenings dumps.

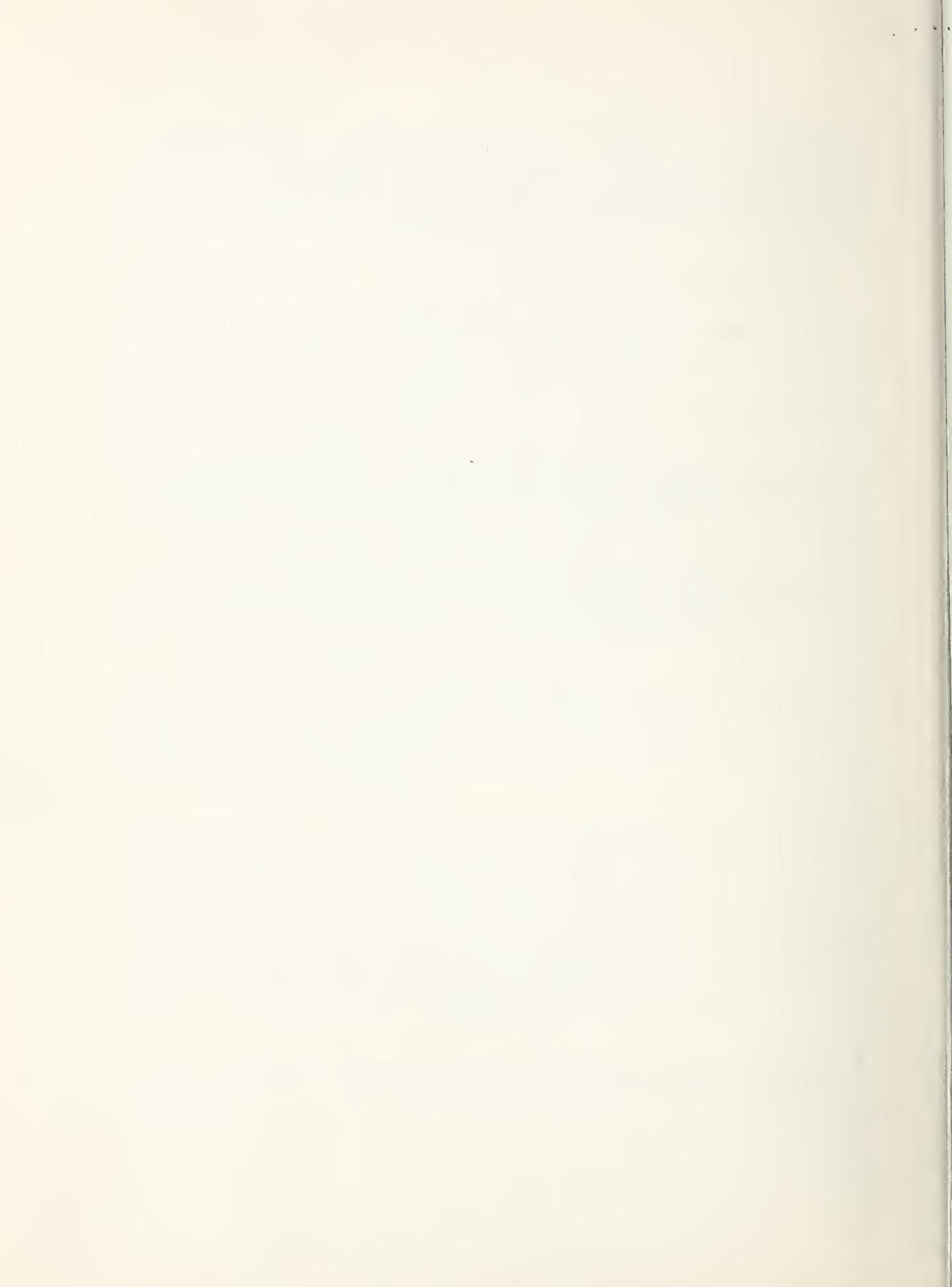
To have all infested screenings destroyed by burning.

To have all out-going shipments of seed and feed fumigated.

All shipments made from infested warehouses during the past two years should be traced and the warehouses receiving them examined for infestations.

Warnings should be given to all feed and grain dealers to be on the look-out for the insect, particularly dealers that deal in seeds from the infested areas.

Richard T. Cotton



HOST MATERIALS OF THE KHAPRA BEETLE

The lists are arranged in order of preferred material.

<u>Processed materials</u>	<u>Unprocessed materials</u>
1. Corn meal	1. Black-eyed peas
2. Rolled oats	2. Sorghum
3. Flour	3. Barley
4. Bread	4. Soybeans
5. Breakfast cereal	5. Peanuts (shelled)
6. Saltine crackers	6. Corn
7. Dog biscuit	7. Pinto beans
8. Minute rice	8. Oats
9. Raisins	9. Wheat
	10. Alfalfa hay
	11. Alfalfa seed
	12. Castor beans
	*13. Peanuts (unshelled)
	*14. Cotton seed
	*15. Wool yarn

* No adults have emerged in these materials. The rating is based on the amount of feeding.





